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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 10/679,341 | 10/07/2003 | Chiaki Kubota | 243767US90X | 2655 |

22820 7590 04/21/2006

CATHIE KIRIK
TEST FOR MORE THAN 26 ATTORNEY REG.#
ANYWHERE, VA 22222

| EXAMINER | |
|---|---|
| COZART, JERMIE E | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 3726 | |

DATE MAILED: 04/21/2006



Please find below and/or attached an Office communication concerning this application or proceeding.

| Office Action Summary | Application No. | Applicant(s) | |
|---|---|---|---|
| | 10/679,341 | KUBOTA, CHIAKI | |
| | Examiner | Art Unit | |
| | Jermie Cozart | 3726 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *22 September 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *1-12* is/are pending in the application.

4a) Of the above claim(s) *7-12* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-6* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *07 October 2003* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

## DETAILED ACTION

### *Election/Restrictions*

1. Applicant's election with traverse of Group I, claims 1-6 in the reply filed on 9/22/05 is acknowledged. The traversal is on the ground(s) that the subject matter of the groups of claims would be part of an overlapping search and therefore not a serious burden on the Examiner. This is not found persuasive for the reasons set forth in the restriction requirement mailed 5/25/05.

The requirement is still deemed proper and is therefore made FINAL.

### *Information Disclosure Statement*

2. The listing of references in the specification is not a proper information disclosure statement. 37 CFR 1.98(b) requires a list of all patents, publications, or other information submitted for consideration by the Office, and MPEP § 609.04(a) states, "the list may not be incorporated into the specification but must be submitted in a separate paper." Therefore, unless the references have been cited by the examiner on form PTO-892, they have not been considered.

### *Drawings*

3. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description: 33. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. Each

drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

***Specification***

4. The disclosure is objected to because of the following informalities: On **page 4**, *line 29*, "be" is objected to because it is grammatically incorrect in the used context, therefore it is suggested to delete "be"; On **page 6**, *line 5*, "pip" is objected to because it is the incorrect word used, therefore it is suggested to change "pip" to - -pipe- -, *line 31*, "cramping" is objected to because it is the incorrect word used, therefore it is suggested to change "cramping" to - -clamping- -; On **page 8**, *line11*, it is suggested to insert - -a- - after "to" in order to grammatically the associated phrase, *line 27*, "of" is objected to because it is grammatically in correct in the used context, therefore it is suggested to change "of" to - -for- -; On **page 10**, *line 28*, "a" is objected to because it is grammatically incorrect in the used context, therefore it is suggested to delete "a"; On **page 12**, *line 27*, "has are" is objected to because it is grammatically incorrect in the used context, therefore it is suggested to change "has are" to - -is- -; On **page 15**, *line 4*, "lack" is objected to because it is the incorrect word used, therefore it is suggested to change "lack" to - -rack- -. Appropriate correction is required.

***Claim Objections***

5. Claims 4-6 are objected to because of the following informalities: In **claim 4**, *line 3*, "performing" is objected to because it is the incorrect word used, therefore it is suggested to change "performing" to - -pre-forming- -, line 7, "pip" is objected to because it is the incorrect word used, therefore it is suggested to change "pip" to - -pipe- -, *line 11*, "it" is objected to because it is the incorrect word used, therefore it is suggested to change "it" to - -its- -; In **claim 5**, *line 7*, "bare" is objected to because it is the incorrect word used, therefore it is suggested to change "bare" to - -bar- -; In **claim 6**, *line 3*, "cramping" is objected to because it is the incorrect word used, therefore it is suggested to change "cramping" to - -clamping- -. Appropriate correction is required.

***Claim Rejections - 35 USC § 112***

6. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

7. Claims 2 and 4-6 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

8. Claim 2 recites the limitation "said adjustment step" in lines 1-2 of the claim. There is insufficient antecedent basis for this limitation in the claim.

9. Claim 4 recites the limitation "the hollow cavity" in line 12 of the claim. There is insufficient antecedent basis for this limitation in the claim.

10. Claim 4 recites the limitation "the inner diameter cavity" in lines 17-18. There is insufficient antecedent basis for this limitation in the claim.

11. Claim 5 recites the limitation "toothed portion" in line 5 of the claim. There is insufficient antecedent basis for this limitation in the claim.

12. Claim 6 recites the limitation "the rack" in lines 4-5 of the claim. There is insufficient antecedent basis for this limitation in the claim.

13. Claim 6 recites the limitation "the toothed portions" in line 9 of the claim. There is insufficient antecedent basis for this limitation in the claim.

***Claim Rejections - 35 USC § 102***

14. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

15. Claims 1-6 are rejected under 35 U.S.C. 102(b) as being clearly anticipated by Oka et al. (US 2001/0006000 A1).

Oka discloses for forging a hollow rack bar from a metal blank pipe (3), comprising (a) subjecting the blank pipe to a plastic deformation process (paragraph [0015]) for an adjustment of a cross-sectional shape of the metal blank pipe; (b) holding the adjusted metal blank pipe by a die having toothed portions so that the toothed portions are contacted with the blank pipe at its outer surface (paragraph [0016]), and (c) inserting, under a pressure, a mandrel (12) into the blank pipe (3) held

by the die (5, 6, 11) for causing the metal to be flown toward toothed portions, thereby forming on the outer surface of the blank pipe toothed portions having shapes corresponding to those of the toothed portions of the die. The adjusting step adjusts the cross-sectional shape of the blank pipe to a predetermined shape (i.e. a flat surface on the pipe 12, fig. 1). The step subjecting the blank pipe (3) to a plastic deformation process for an adjustment of a desired cross-sectional shape of the metal blank pipe comprises subjecting the blank pipe to swaging process (paragraph [0015]) for reducing the diameter of the blank pipe, and subjecting the swaged pipe to an ironing process (paragraph [0015], lines 14-24) for producing a desired cross-sectional shape of the blank pipe. *See paragraphs [0014] – [0019], and figures 1-5 and 7 for further clarification.*

Oka discloses for forging a hollow rack bar from a metal blank pipe (3), comprising a pre-forming step (paragraph [0015]) and a main forming step (paragraph [0016]) after the execution of the pre-forming step, the pre-forming comprises the steps of: (a) subjecting the blank pipe to swaging process for reducing the diameter of the blank pipe; (b) clamping the swaged blank pipe by a clamping die (5, 6) of a desired shape at the outer periphery thereof, while locating a working core (10) inside the blank pipe, and; (c) withdrawing the working core (10) so that the blank pipe is swaged at its inner diameter side, thereby generating a desired shape of the hollow cavity of the blank pipe (3) extending in an axial and radial directions; the main forming comprises the steps of: (d) holding the pre-formed blank pipe from its outer side by a rack forming die (5, 6, 11) having toothed portions; and (e) inserting, under a pressure, a mandrel (12) to the inner diameter cavity of the blank pipe, thereby

forming on the outer surface of the blank pipe, toothed portions having shapes corresponding to those of the rack forming die (5, 6, 11). *See paragraphs [0014] – [0019], and figures 1-5 and 7 for further clarification.*

Oka discloses for forging a hollow rack bar from a metal blank pipe (3), wherein the blank pipe (3) is, from its outer side, held by a rack forming die (5, 6, 11), and a mandrel (12) is inserted to the blank pipe (3) under a pressure, thereby forming a hollow rack bar having shape corresponding to toothed portion of the rack forming die, the improvement wherein prior to the forging of the hollow rack bar, the blank pipe is subjected to a plastic deformation process (paragraph [0015]) for obtaining an adjustment of the cross-sectional shape of the blank pipe. *See paragraphs [0014] – [0019], and figures 1-5 and 7 for further clarification.*

Oka discloses forging a hollow rack bar from a blank metal pipe (3), comprising the steps of: (a) holding the blank pipe by means of a clamping die (5, 6, 11) having, at its inner periphery, toothed portion for forming the rack, and (b) inserting, at a pressure, a mandrel (12) into the blank pipe (3), while, during the insertion, the mandrel causes the metal to be subjected to simultaneous expanding functions at different locations of the toothed portions along the longitudinal direction, thereby forging the blank pipe to a hollow rack bar. *See paragraphs [0014] – [0019], and figures 1-5 and 7 for further clarification.*

***Conclusion***

16. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. The references cited on the attached PTO-892 are cited to show the formation of hollow rack bars.

17. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Jermie Cozart whose telephone number is 571-272-4528. The examiner can normally be reached on Monday-Thursday, 7:30 am - 6:00 pm.

18. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, George Nguyen can be reached on 571-272-4491. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

19. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Jermie Cozart
Examiner
Art Unit 3726

JC
April 15, 2006

| Notice of References Cited | Application/Control No. 10/679,341 | Applicant(s)/Patent Under Reexamination KUBOTA, CHIAKI | |
|---|---|---|---|
| | Examiner Jermie Cozart | Art Unit 3726 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| * | A | US-6,925,899 b2 | 08-2005 | Ozeki, Keita | 74/422 |
| * | B | US-6,718,813 B2 | 04-2004 | Yasuda et al. | 72/370.04 |
| * | C | US-6,575,009 B2 | 06-2003 | Shiokawa, Seiji | 72/370.06 |
| * | D | US-6,494,073 B2 | 12-2002 | Oka et al. | 72/356 |
| * | E | US-6,442,992 B2 | 09-2002 | Tsubouchi et al. | 72/370.21 |
| * | F | US-6,289,710 B1 | 09-2001 | Ozeki, Keita | 72/370.04 |
| * | G | US-2001/0006000 A1 | 07-2001 | Oka et al. | 72/356 |
| * | H | US-4,598,451 | 07-1986 | Ohki, Takanosuke | 29/893.3 |
| * | I | US-4,133,221 | 01-1979 | Clary, Harry E. | 74/498 |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | Classification |
|---|---|---|---|---|---|---|
| | N | JP 63212175 A | 09-1988 | Japan | SUGIYAMA et al. | |
| | O | JP 58081535 A | 05-1983 | Japan | SATO et al. | |
| | P | JP 56062734 A | 05-1981 | Japan | SAGA, HIROSHI | |
| | Q | GB 2061138 A | 05-1981 | United Kingdom | Hoare, David J. | |
| | R | GB 2026908 A | 02-1980 | United Kingdom | Bishop, Arthur E. | |
| | S | | | | | |
| | T | | | | | |

**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|---|
| | U | |
| | V | |
| | W | |
| | X | |

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PAT-NO: JP363212175A

DOCUMENT-IDENTIFIER: JP 63212175 A

TITLE: MANUFACTURE OF RACK FOR RACK-AND-PINION TYPE STEERING

PUBN-DATE: September 5, 1988

INVENTOR-INFORMATION:
NAME
SUGIYAMA, EIHIKO
TOYOHARA, YOICHI
MORISHITA, KOICHI

INT-CL (IPC): B62D003/12

US-CL-CURRENT: 29/897.2

ABSTRACT:

PURPOSE: To manufacture a convex rack easily by heating near the central part of a rack material at a temperature lower than those at the both ends, and executing a forging process in the condition to give a temperature incline in the axial direction of the rack material.

CONSTITUTION: When a convex rack with a size larger as being closer to the center is manufactured, an upper pattern 4 to form teeth 2 to a rack material 1 and a lower pattern 5 to form a rack guide 3 to the rack material 1 are prepared as metal molds. And the rack material 1 heated at the center at a temperature lower than those at the both ends is the heating process is placed between the upper and lower patterns 4 and 5, and a striking force is applied to forge to manufacture a desired rack. Since the deformation resistance at the center of the rack material 1 is larger than those near the both ends in this case, the elastic deformation of the upper and lower patterns 4 and 5 is produced larger at the center than at the both ends, and the teeth 2 of the rack are also larger at the center than at the both ends. Consequently, the rack guide 3 is also made larger as being closer to the center.



---------- KWIC ---------

Document Identifier - DID (1):
JP 63212175 A

Current US Cross Reference Classification - CCXR (1):
29/897.2

⑲日本国特許庁(JP)　⑪特許出願公開

⑫公開特許公報(A)　昭63－212175

| ⑤1Int.Cl.⁴ | 識別記号 | 庁内整理番号 | ⑬公開　昭和63年(1988)9月5日 |
|---|---|---|---|
| B 62 D 3/12 | | 8009－3D | |

審査請求　有　発明の数 1　(全3頁)

⑤4発明の名称　ラックアンドピニオン式ステアリングのラックの製造方法

⑳特　願　昭63－24655
㉒出　願　昭57(1982)8月24日
前実用新案出願日援用

⑦2発明者　杉山　栄彦　愛知県豊田市トヨタ町1番地　トヨタ自動車株式会社内
⑦2発明者　豊原　洋一　愛知県豊田市トヨタ町1番地　トヨタ自動車株式会社内
⑦2発明者　森下　弘一　愛知県豊田市トヨタ町1番地　トヨタ自動車株式会社内
⑦1出願人　トヨタ自動車株式会社　愛知県豊田市トヨタ町1番地
⑦4代理人　弁理士　尊　優美　外1名

## 明細書

1.発明の名称

ラックアンドピニオン式ステアリングの
ラックの製造方法

2.特許請求の範囲

(1)ラック材の中央部付近の温度を両端部近傍の温度より低く加熱し、ラック材の軸方向に温度勾配を与えた状態で鍛造を行なうことにより、中高のラックを製造することを特徴とするラックアンドピニオン式ステアリングのラックの製造方法。

3.発明の詳細な説明

(産業上の利用分野)

本発明はラックアンドピニオン式ステアリングにおけるラックの鍛造による製造方法に関する。

(従来の技術)

従来、自動車に使用される、ラックアンドピニオン式のステアリングのラックを製造する方法の一つとして鍛造によるものがある。

これは、ラックを製造するための基材である棒状のラック材を軸方向に均一に加熱した後、第1図に示すように、加熱したラック材1を、ラック材1に歯2を形成する上型4と、ラック材1にラックガイド部3を形成する上型5とで型打ちしてラックを製造するものである。

(発明が解決しようとする課題)

しかしながら、上記従来の製造方法では、ラックの歯2とラックガイド部3との厚さ(ラックの太さ)は右据切部から左据切部までほぼ一定となるように製造されるが、鍛造成形時における厚さのバラツキ、歯面焼入れ時の歪、ラックガイドの製品精度等によりステアリングが据切時よりもニュートラル付近でのラックガイドクリアランスが大きくなることがあり、それにより、コトコト音が生じて車の直進走行時のノイズの発生原因となっているという問題が生じていた。

本発明は、以上の問題に鑑みてなされたもので、その目的とするところは、簡単な方法で、

ラックを中高となるように製造し、ニュートラル付近のラックガイドクリアランスを積極的に小さくすることにある。

（課題を解決するための手段）

上記目的を達成するラックの製造方法として、ラック材1の中央部付近の温度を両端部近傍の温度より低く加熱し、ラック材1の軸方向に温度勾配を与えた状態で鍛造を行なうものである。

（作用）

この方法によると、ラック材1の中央部付近の温度が低いため、中央部付近の鍛造時の変形抵抗がラック材1の左右両端部近傍より大きくなる。そのため、鍛造する金型4，5においてラック材1の中央部付近を加工する部位が左右の両端部近傍を加工する部位より大きく弾性変形することとなり、中央部に向かうにつれて太くなる中高のラックが製造される。

このような、中高のラックをステアリングに用いると、ニュートラル付近のラックガイドクリアランスが小さくなる。

（実施例）

つぎに、第1図、第2図を用いて本発明の実施例を説明する。

まず、鍛造成形前のラック材1の加熱工程には、ラック材1の加熱温度を軸方向に徐変させられるように、コイル径が変更された高周波誘導加熱機（図示せず）が設けられている。これによつて、ラック材1の中央部の温度を両端近傍の温度より低く加熱することができる。

つぎに、ラックを鍛造するための金型は、従来の技術で説明したものと同一で、ラック材1に歯2を形成する上型4と、ラック材1にラックガイド部3を形成する上型5とから構成されている。

この構成によるラックの製造方法を説明すると、加熱工程で中央部が両端部より低く加熱する。つづいて、軸方向に温度勾配が与えられたラック材1を、上型4と下型5の間に挟み衝撃力を加えて鍛造することにより、ラックが製造される。このとき、軸方向の温度勾配によつて、ラック材1の中央部の変形抵抗が両端部近傍より大きくなつているため、上型4と下型5とは、第1図中の2点鎖線や破線のように端部側より中央部がより大きな弾性変形をすることとなる。その結果、ラックの歯2は、端部2bより中央部2aが大きくなり、かつとラックガイド部3も中央部に行くに従い太くなる。

さらに、型打終了後、ラック材1を鍛造型より取り出して冷却すると、端部側の方が温度が高いために中央部より大きな材料収縮が生じ、中高傾向はより一層顕著になる。

（発明の効果）

以上詳細に説明したように、本発明の製造方法では、ラック材の温度を中央部が両端部より低くなるように加熱するだけで、鍛造成形により中高のラックが製造することができる。

そのため、このように製造したラックを用いたステアリングではニュートラル付近におけるラックガイドクリアランスを積極的に小さくすることができ、コトコト音を防止して、車の直進走行時にステアリングから発生するノイズを低減する。

さらに、本発明の製造方法に使用する設備は、従来の設備に対して大きな変更を要することがないため、設備費や製造コストを上昇させることなく、ノイズ低減に効果的なラックを提供できることとなる。

4.図面の簡単な説明

第1図は本発明の鍛造時におけるラック材の変形状態を示す縦断面図、第2図は第1図の中央部の横断面図である。

1・・・ラック材

4・・・上型

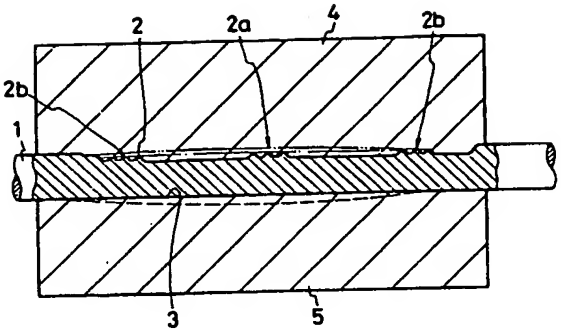
5・・・下型

特許出願人　トヨタ自動車株式会社

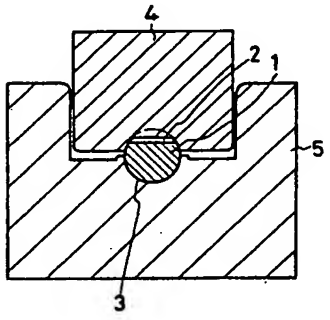
代理人　弁理士　弓　恆　美

（ほか1名）

第1図




第2図



PAT-NO: JP358081535A

DOCUMENT-IDENTIFIER: **JP 58081535 A**

TITLE: MANUFACTURE OF RACK FOR RACK AND PINION STEERING DEVICE

PUBN-DATE: May 16, 1983

INVENTOR-INFORMATION:
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MIYOSHI, KOJIRO
MAEJIMA, KEIICHI

INT-CL (IPC): B21K001/06

US-CL-CURRENT: **72/352**

ABSTRACT:

PURPOSE: To obtain a tooth form excellent in surface roughness and strength by preforming a tooth form lower in height and wider in width than final tooth form and then obtaining required final tooth form by finishing work and thereby reducing amount of cutting.

CONSTITUTION: A tooth form part 13 is formed flat in specified position of a rack material 11 made of a solid round bar, and a tooth form 12 is preformed in the tooth form part 13. The tooth form 12 has a profile lower in height and wider in width than the final tooth form 16. The volume of the tooth form 12 is made substantially equal to that of the final tooth form 16 to obtain required final tooth form by succeeding finishing work, for instance press work. Then, the tooth form 12 of the rack material 11 is finished to the final tooth form 16 by a die provided with a die which is corresponding exactly to the final tooth form 16.



---------- KWIC ---------

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**JP 58081535 A**

Current US Cross Reference Classification - CCXR (1):
**72/352**

⑲ 日本国特許庁 (JP)　　⑪ 特許出願公開

⑫ 公開特許公報 (A)　　昭58—81535

⑤1Int. Cl.³　識別記号　庁内整理番号　⑬公開　昭和58年(1983)5月16日
B 21 K 1/06　7139—4E

発明の数　1
審査請求　未請求

(全 3 頁)

# ⑤4ラックアンドピニオンかじ取り装置用ラックの製造方法

⑳特　願　昭56—177036
㉒出　願　昭56(1981)11月6日
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## 明　細　書

### 1.発明の名称

ラックアンドピニオンかじ取り装置用ラックの製造方法

### 2.特許請求の範囲

1. ラックアンドピニオンかじ取り装置用のラックを形成するに際し、ラック素材にまず最終歯形よりも高さが低く、かつそれよりも歯幅が広い歯形をプリ成形してこの歯形の体積と最終歯形の体積とを実質的に等しくし、次いで、最終歯形に対応する型を設けたダイスで前記プリ成形歯形を最終歯形に仕上げ加工することを特徴とするラックアンドピニオンかじ取り装置用ラックの製造方法。
2. プリ成形を、冷間鍛造，熱間鍛造，温間鍛造または冷間鍛造のいずれかによつて行うことを特徴とする特許請求の範囲第1項記載のラックアンドピニオンかじ取り装置用ラックの製造方法。
3. 仕上げ加工を熱間鍛造，温間鍛造または冷間鍛造のいずれかによつて行うことを特徴とする特許請求の範囲第1項もしくは第2項記載のラックアンドピニオンかじ取り装置用ラックの製造方法。

### 3.発明の詳細な説明

この発明はラックアンドピニオンかじ取り装置用ラック、とくに可変かじ取り比を与えるラックの製造方法に関するものである。

従来のこの種のラックの製造方法としては、たとえば特公昭56－26528号公報に記載されたものがある。この方法は、第1図に示すように、丸棒からなるラック素材1の所定位置にたとえば機械加工，鍛造加工などによつてラック歯形1aをプリ成形してこのラック歯形1aの断面形状を、第2図に破線で示すように、そこに実線で示す最終歯形2よりも丈高にするとともに、その歯元部分の幅が最終歯形2のそれよりも狭くなるようにし、しかる後，ダイスによつてラック歯形1aを所要の最終歯形2に冷間加工するものである。

この方法によれば、とくに冷間加工によつてラック歯形1aの頂部からその歯元へ向けて次第に

成形が進行し、その加工終了時には所要の最終歯形2が得られる。

しかしながら、このような従来技術にあつては、プリ成形によつて形成されるラック歯形1aが最終歯形2よりも丈高であるため、

① プリ成形を機械加工にて行う場合には、切削量が極めて多くなる。

② プリ成形を鍛造加工にて行う場合には、成形型の凸部の高さが高くなつて型摩耗し易いとともに、歯形部分を型内へ完全に入り込ませ難い。

などの問題があり、また冷間加工でラック歯形1aの頂部を押しつぶすことによつて最終歯形2を形成しているため、

① ダイス内での材料流れが生じ難く、特に最終歯形の歯面に沿つて一様な材料流線が生じ難のため最終歯形の表面粗度が悪い。

② 加えて材料が断面横方向に流動して動力伝達を行う歯面を形成することから、最終歯形2の強度が低い。



などの問題があつた。

この発明は従来技術のこのような問題を有利に解決したラックの製造方法を提供するものであり、とくに機械加工または熱間，温間もしくは冷間鍛造加工のいずれかによつてラック素材に最終歯形よりも高さが低く、かつそれよりも歯幅が広い歯形をプリ成形してこの歯形の体積と最終歯形の体積とを実質的に等しくし、次いで最終歯形と対応する型を設けたダイスで前記プリ成形歯形を最終歯形に仕上げ加工することによつて、ラックの製造を有利ならしめるとともに、ダイス内での有効な材料流れに基く最終歯形の表面粗度および強度の向上をもたらすものである。

以下にこの発明を図面に基いて説明する。

第3図はこの発明の成形工程を例示する断面図であり、第3図(a)は中実丸棒からなるラック素材11の所定位置に機械加工、または熱間，温間もしくは冷間鍛造加工のいずれかによつて歯形部分13を偏平に形成した状態を示す断面図、第3図(b)は歯形部分13に機械加工、または熱間，温間もしくは冷間鍛造加工のいずれかによつて歯形12をプリ成形した状態を示す断面図である。



従つてプリ成形後のラック素材11は歯形部分13と、この歯形部分13に隣接する円柱状軸部14，15とを有する。

ここで歯形12は、第4図に拡大断面図で示すように、そこに破線で示す最終歯形16よりも高さが低く、かつそれよりも歯幅が広い断面形状を有する。また、歯形12の体積は、引き続く仕上げ加工であるたとえばプレス加工によつて所要の最終歯形16を得るために、最終歯形16のそれと実質的に等しくする。なお、好ましくは歯形12の断面積が最終歯形16のそれと等しくなるようにしてプレス加工における歯形12の流動が実質的に該ラック素材11の軸線と直行する方向に生じるのを防止する。

次いで、最終歯形16に正確に対応する型を設けたダイスによつて、ラック素材11の歯形12を第3図(b)に示すように最終歯形16に仕上げ加工する。この仕上げ加工によつて歯形12は、第4図に破線で示すように歯幅の狭い丈高の最終歯形16になる。



歯形12から最終歯形16へのかかる成形は、歯形12の両側面への押圧力で歯頂部分を押し上げるように進行するので、ダイス内での材料流動は比較的容易に行なわれ、最終歯形16の内部に第5図に細線で示すように、全体として最終歯形16の輪郭に沿う材料流線17をもたらすので従来技術によつてもたらされるそれよりも最終歯形16の表面粗度が向上するとともに強度が著しく向上する。さらには動力伝達を行う歯面の大部分はプリ成形によつて成形された部分を押し縮めて成形しているので歯車の強度向上に一層寄与している。

上述したような最終歯形16を得るための仕上げ加工は、たとえば第6図に示すようにプリ成形を終了したラック素材11を、下金型18のラック素材11と対応する形状の受け部19内に配置し、また曲がり防止用クランプ20，21を下降させることによつて、ラック素材11の円柱状軸部14，15を受け部19内に確実に拘束し、次いでダイスとしての上金型22を所定位置まで押し込み、最終歯形16と正確に対応するその型によつて、歯形12を最終歯形16

に成形することにより行うことができる。

以上述べたように、この発明によれば最終歯形よりも丈が低く、歯幅の広い歯形をプリ成形し、しかる後仕上げ加工によつて所要の最終歯形を得ることとしたため、プリ成形時の切削量の減少または型の摩耗防止、加えて表面粗度ならびに強度のすぐれた最終歯形を得ることができる。

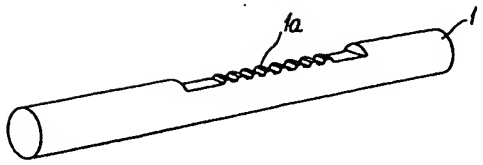
4 図面の簡単な説明

第1図は従来技術のプリ成形歯形を示す斜視図、第2図は従来技術のプリ成形歯形と最終歯形との関係を示す説明図、第3図はこの発明の成形工程を例示する側面図、第4図はこの発明に係るプリ成形歯形と最終歯形との関係を示す拡大断面図、第5図は最終歯形の材料流線を示す説明図、第6図は最終歯形の冷間加工状態を示す断面図である。

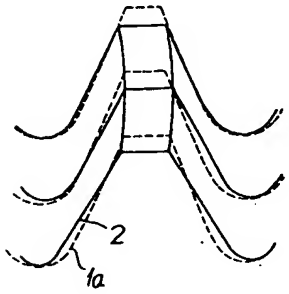
11…ラック素材、12…歯形、13…歯形部分、14，15…円柱状軸部、16…最終歯形、17…材料流線。



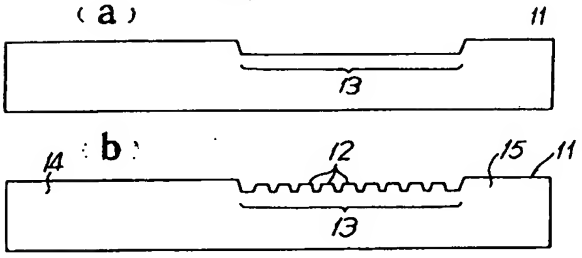
第1図



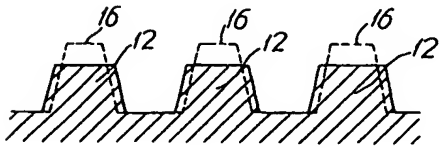

第2図



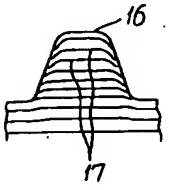

第3図



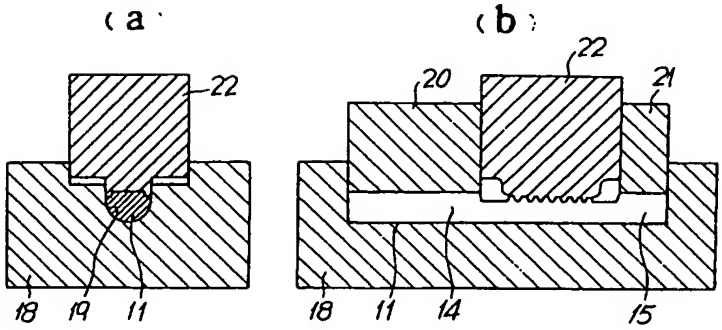

第4図




第5図




第6図



PAT-NO: JP356062734A

DOCUMENT-IDENTIFIER: JP 56062734 A

TITLE: MANUFACTURE OF RACK

PUBN-DATE: May 28, 1981

INVENTOR-INFORMATION:
NAME
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INT-CL (IPC): B23P015/14

US-CL-CURRENT: 29/893.34, 72/324

ABSTRACT:

PURPOSE: To manufacture easily and in quantity even linear or variable-ratio racks by applying a process forging rack teeth and a process for forging the teeth so as to provide the same form with that of the rack teeth to be manufactured.

CONSTITUTION: First a round bar material having a prescribed diameter is cut in a prescribed length by a cutting process, whereby a rack material 12 is obtained. Upper and lower dies 10 and 11 have the forms whereby the material 12 can be forged to have a form approximate to the one of the variable-ratio rack to be manufactured finally. And the lower die 11 has tooth-die parts 11a and 11b for forming the rack teeth 3a and 3b. Moreover, the forms of the rack teeth 3a and 3b are constituted in such a manner that the final rack teeth of the variable-ratio rack 2 to be manufactured and tilt surfaces 2a thereof can be forged thereby. Accordingly, this cold forging, the substantial rack teeth 3a and 3b can be manufactured easily and in quantity.



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29/893.34

⑲ 日本国特許庁（JP）　　⑪ 特許出願公開

⑫ 公開特許公報（A）　　昭56—62734

| ⑤1Int. Cl.³ | 識別記号 | 庁内整理番号 | ⑬公開　昭和56年(1981)5月28日 |
|---|---|---|---|
| B 23 P 15/14 | | 6660—3C | |

発明の数　1
審査請求　未請求

（全 6 頁）

# ⑤4ラックの製造方法

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⑦2特　　願　昭54—139082
⑦3出　　願　昭54(1979)10月27日

⑦2発　明　者　嵯峨弘

明　細　書

1. 発明の名称

ラックの製造方法

2. 特許請求の範囲

(1)丸棒状ラック素材に、製造すべきラック歯の形状に近似したラック歯を鍛造加工により形成する第１の工程と、この第１の工程により得られたラック歯を、製造すべきラック歯の形状と実質的に同一の形状に鍛造加工する第２の工程とを有することを特徴とするラックの製造方法。

(2)ラックが、直線のラック歯と湾曲したラック歯とを有する可変比ラックであることを特徴とする特許請求の範囲第１項記載の製造方法。

(3)第１の工程が、ラック歯の反対面側を断面略Ｙ字状に同時に鍛造加工することを特徴とする特許請求の範囲第１項又は第２項記載の製造方法。

3. 発明の詳細な説明

本発明はラックの製造方法に関し、特にラックピニオン式舵取装置に用いられる可変比ラックの製造に好適な製造方法に関する。

－ 1 －

従来、可変ステアリング比率型のラックピニオン式舵取装置として、可変比ラックを用いたものが知られている（特公昭５２－２９０４９号公報）。第１図はそのようなラックピニオン式舵取装置の断面図を示したもので、ケーシング(1)内にラック(2)を摺動自在に嵌合させ、そのラックのラック歯(3)に図示しない舵取ハンドルに連動させたヘリカルピニオン(4)を噛合させている。またラック歯(3)を形成した反対面側部分は、第２図のように、その断面を略Ｙ字状に形成し、その両側の傾斜面(2a)，(2a)に筒状部材(5)の両側案内面(5a)，(5a)を摺接させている。この筒状部材(5)は上記ケーシング(1)内にラック(2)の軸方向と直交する方向に摺動自在に嵌合され、かつばね(6)により附勢されてラック歯(3)をヘリカルピニオン(4)側に附勢している。上記ラック(2)は、可変ステアリング比率を得るために可変比ラックとして構成され、そのラック歯(3)の形状は、第３図に示すように、両側が直線のラック歯(3a)として、中央部が湾曲したラック歯(3b)として形成されている。この中央部の湾曲したラ

－ 2 －

ック歯 (3b)の形状については上記公報に詳細に記載されており、このラック歯 (3b)により、第4図に示すように、その両側の直線のラック歯 (3a)に対して、小さな又は大きなステアリング比率を得ることができる。

然して、上記可変比ラック(2)を一品生産若しくは少益生産的に製造することはできるが、これを大量生産することは必ずしも容易ではない。従来、そのような可変比ラックのラック歯(3)をその最終的な形状に近接した形状にまでブローチ加工できるようにした装置は既に提案されているが（特開昭54－125597号公報）、最終的なラック歯(3)の形状を得るには依然として一品製産的若しくは少益生産的な製造方法に頼らざるを得なかつた。

本発明はこのような点に鑑み、通常の直線のラック歯のみを有するラックはもとより、上記湾曲したラック歯を有する可変比ラックであつても、これを容易に、かつ大量に製造し得る製造方法を提供することを目的とするものである。

本発明に係る製造方法は、丸棒状ラック素材に、



製造すべきラック歯の形状に近似したラック歯を鍛造加工により形成する第1の工程と、この第1の工程により得られたラック歯を、製造すべきラック歯の形状と実質的に同一の形状に鍛造加工する第2の工程とを有することを特徴とし、ラック歯を第1，第2の工程の鍛造加工によつて得るようにしているので、製造すべきラック歯の形状を自由に設定でき、したがつて直線のラック歯であつても、湾曲したラック歯であつても自由に高精度で量産することができる。そして第1の工程における鍛造加工時に、又は第1と第2の工程の鍛造加工によつて、同時にラック歯の反対面側を断面略Y字状として上記傾斜面 (2a)，(2a) を形成することができるので、その傾斜面を形成する工程とラック歯を形成する工程とを別個なものとした場合に比して、製造工程の簡素化を図ることができる。

以下図示実施例について本発明の製造方法を説明する。第5図は本発明の製造工程を示すブロック図で、まず切断工程により所定の径を有する丸



棒素材を所定の長さに切断してラック素材を得る。そしてこのラック素材に適当な熱処理を施して金属組織の均一化を図つた後、温間鍛造が行なわれる。第6図はこの温間鍛造に用いられる上型(10)と下型(11)との断面図、第7図は下型(11)の平面図で、これらの型(10)，(11)は、上記ラック素材(12)を最終的に製造する可変ラックに近似した形状に鍛造し得る形状となつている。そして下型(11)は、前述のラック歯 (3a)，(3b) を形成するための歯型部 (11a)，(11b) を有し、また上型(10)はラック素材(12)を断面略Y字状に形成してその両側に前述の傾斜面(2a)，(2a)を形成するための傾斜部 (10a)，(10a) を有している。

上記上型(10)及び下型(11)によりラック素材(12)を最終的な可変ラックに近似した形状に鍛造したら、次に焼鈍等の適当な熱処理を施して内部応力の解除と金属組織の均一化を図つた後、冷間鍛造が行なわれる。この冷間鍛造に用いられる上型並びに下型は図示してないが、基本的には第6図，第7図に示した温間鍛造の上型(10)並びに下型(11)と同様



なものであつて、ただ (3a)，(3b) それらの形状は、製造すべき最終的な可変比ラック(2)のラック歯と傾斜面 (2a)，(2a) とを鍛造し得るように構成されている。したがつてこの冷間鍛造により、実質的なラック歯 (3a)，(3b) の製造は完了する。

上記冷間鍛造が終了したら再び適当な熱処理が施されて内部応力の解除と金属組織の均一化が図られ、次にバリ取りが行なわれた後、末端部に連結用のねじ穴を形成する、或いはストッパリングの係合用溝を形成する等の両端加工が施される。この後、焼入れ、焼戻し等の熱処理やIHT（高周波焼入れ）、製品の曲り直し、バフ加工、円筒研削が順次行なわれ、磁気探傷検査及び最終検査を経て全製造工程が終了する。

なお、本発明の第1の工程に相当する上記温間鍛造は、複数回の温間鍛造或いは温間鍛造と冷間鍛造との組合せから構成することができる。

以上述べたように、本発明の製造方法によれば、直線のラック歯はもとより湾曲したラック歯であつても直線のラック歯と同様に極めて容易に成形

することができ、大量生産に適している。そして細かな切削部分を除き、大部分を第1，第2の工程の鍛造加工によつて形成することができるので材料の歩留まりがよく、またラック歯の反対面側を断面略Y字形とする場合には上記鍛造加工を利用することができるので、製造工程の簡素化を図ることができる等の効果が得られる。

4. 図面の簡単な説明

第1図は従来公知の可変ステアリング比率型のラックピニオン式舵取装置を示す横断平面図、第2図は第1図のII－II線に沿う断面図、第3図は第1図，第2図のラックピニオン式舵取装置に用いられる可変比ラックを示す拡大平面図、第4図はステアリング比率の変化の状態を示す特性曲線図、第5図は本発明に係る製造方法の一実施例を示す製造工程図、第6図は第5図に示す温間鍛造に用いられる上型と下型とを示し、第7図のVI－VI線に沿う断面図、第7図は第6図の下型の平面図である。

(2)：ラック　　(2a)：傾斜部



(3)：ラック歯　　(3a)：直線のラック歯

(3b)：湾曲したラック歯

(10)：上型　　(11)：下型

(12)：ラック素材

特許出願人　自動車機器株式会社

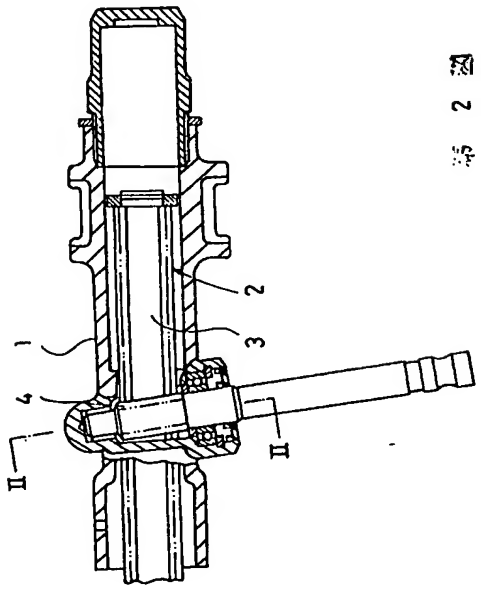
代理人　弁理士　山崎宗秋

同　神崎真一郎

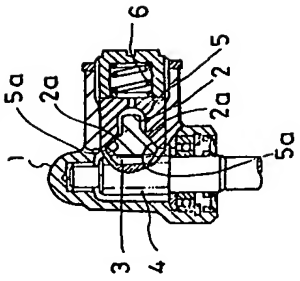
同　三浦邦夫



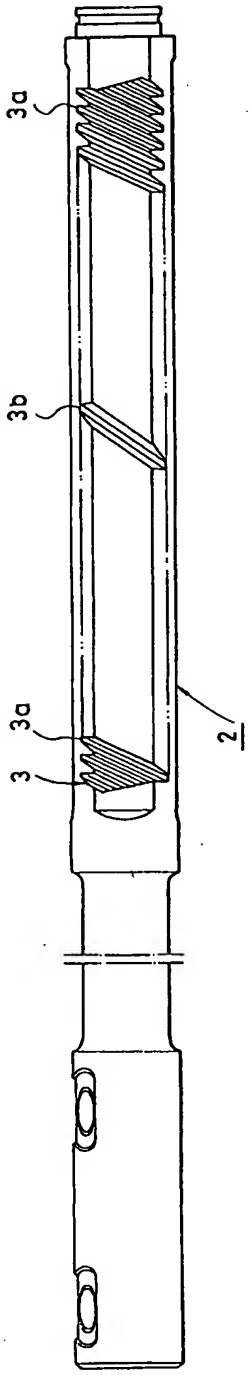
第1図



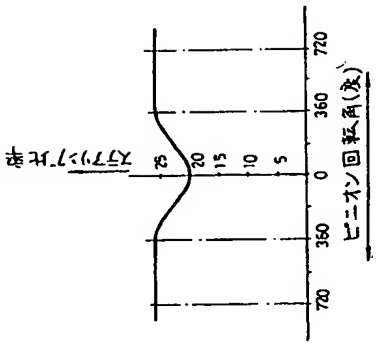

第2図



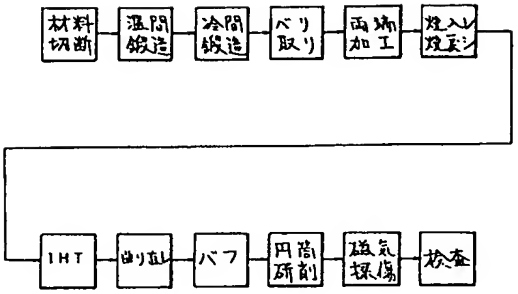
第3図



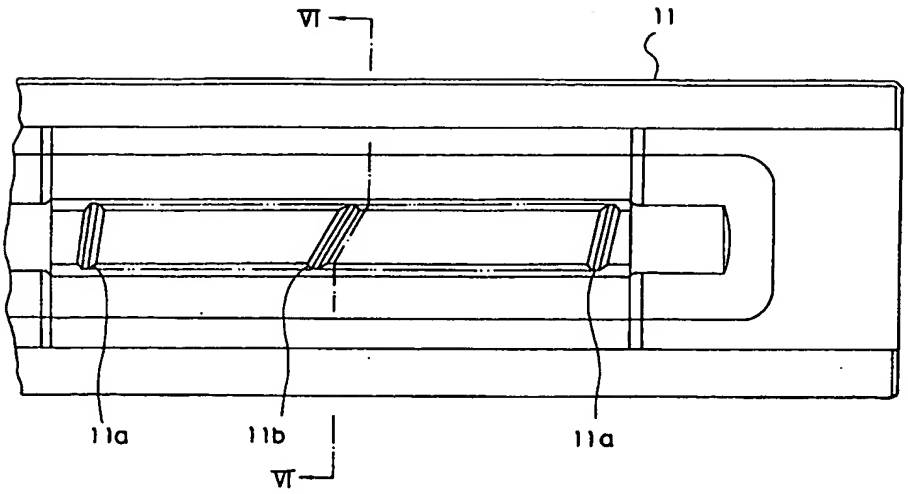

第4図



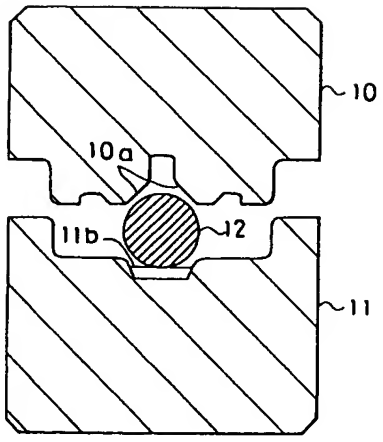
第 5 図


材料切断
温間鍛造
冷間鍛造
バリ取り
両端加工
焼入焼戻
IHT
曲り直し
バフ
円筒研削
磁気探傷
検査

第 7 図


VI
11
11a
11b
11a
VI

第 6 図


10
10a
11b
12
11

手　続　補　正　書（自発）

昭和５５年２月２０日

特許庁長官　川　原　能　雄　殿

1. 事件の表示

昭和５４年特許願第１３９０８２号

2. 発明の名称

ラックの製造方法

3. 補正をする者

事件との関係　　特許出願人

住　所　東京都渋谷区代々木２丁目１０番１２号

名　称　自動車機器（ジドウシャキキ）株式会社

4. 代理人

住　所　東京都中央区日本橋本町１丁目４番地
中山ビル４階

氏　名　（７３３６）弁理士　山　崎　宗　秋

電話０３（２４１）３０４６番


5. 補正の対象

明細書の発明の詳細な説明の欄

6. 補正の内容

(1) 明細書第６頁第１行の「(3a)、(3b)」という記載を削除する。

(2) 明細書第６頁第２行の「ラック歯」という記載を「ラック歯(3a)、(3b)」と補正する。

以上

(12) UK Patent Application (19) GB (11) 2 061 138 A

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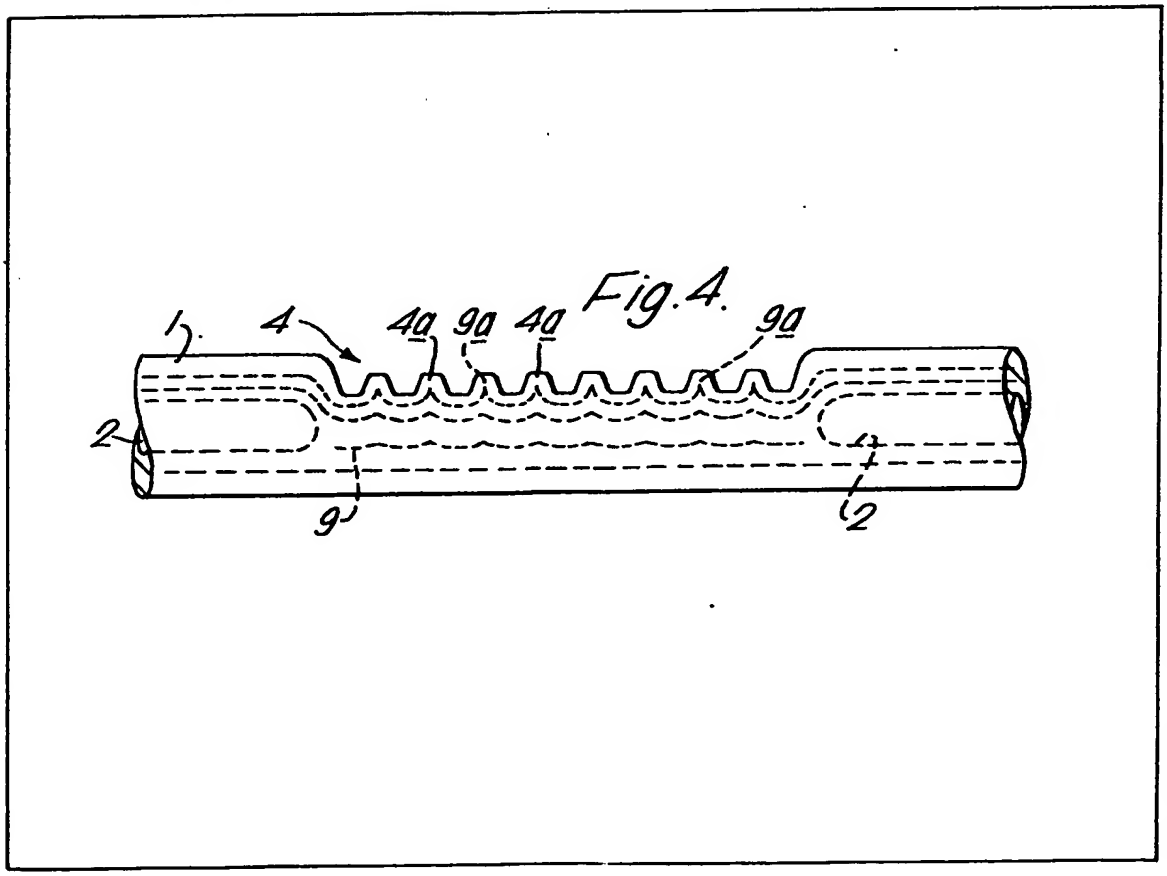
(22) Date of filing 24 Oct 1979
(43) Application published 13 May 1981
(51) INT CL³ B21D 53/88
(52) Domestic classification B3A 73 B3H 2U
(56) Documents cited None
(58) Field of search B3A B3H
(71) Applicants Cam Gears Limited, 45 Wilbury Way, Hitchin, Hertfordshire
(72) Inventor David James Hoare
(74) Agents Urquhart-Dykes & Lord, 11th Floor, St. Martin's House, 140 Tottenham Court Road, London, W1P 0JN

(54) Manufacture of rack member for rack and pinion assembly

(57) A longitudinally extending rack member for a rack and pinion assembly is formed from a tubular metal bar 1 having longitudinally extending grain 9 over the length of the bar within which the rack teeth 4a are to be formed. The rack teeth 4a are formed by collapsing the wall of the bar 1 to close its bore 2 and by coin pressing the collapsed wall between opposed dies so that the metal grain 9a follows the form of each tooth and each tooth 4a is devoid of end grain. For a thin walled tubular bar, a tubular plug can be located in the bore of the tubular bar and the walls of the bar and plug are subsequently collapsed to close the bore of the plug. The walls are coin pressed to form the rack teeth.




GB 2 061 138 A

Fig. 1.

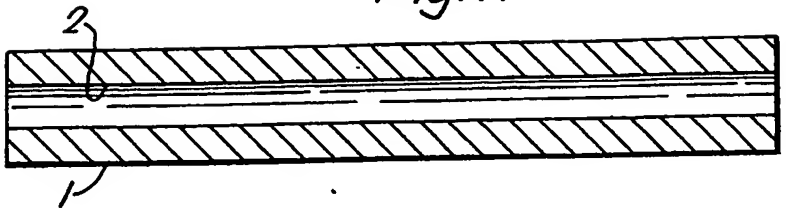



Fig. 2.

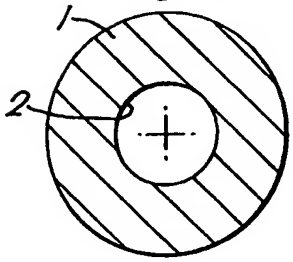



Fig. 5.

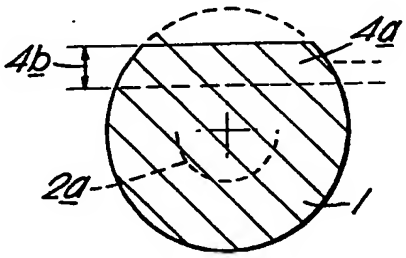



Fig. 6.

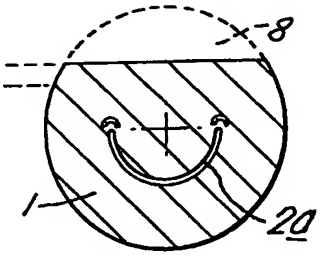



Fig. 3.

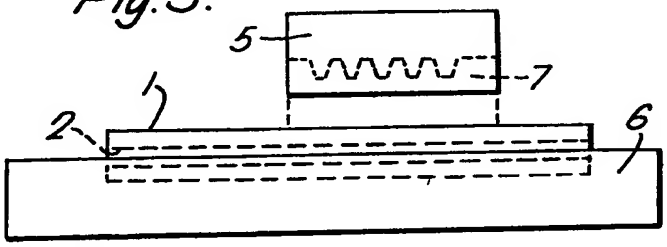



Fig. 4.

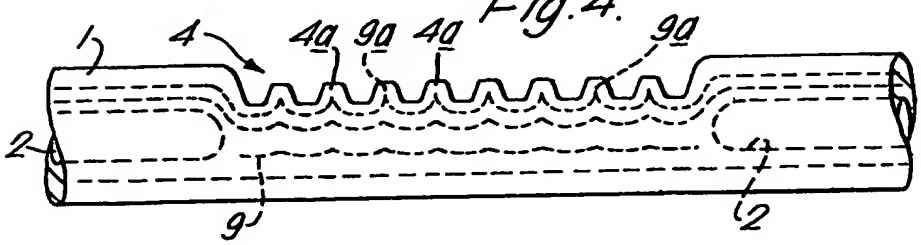
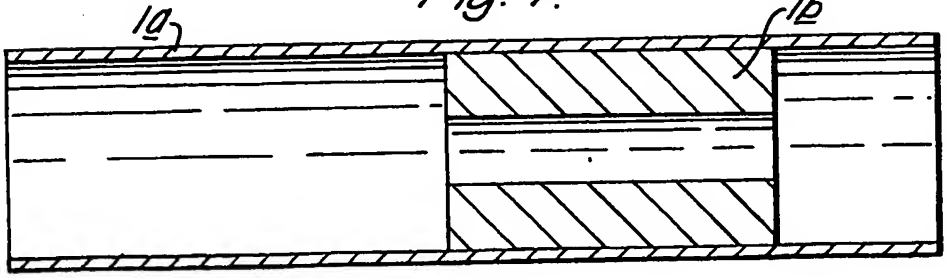



Fig. 7.



SPECIFICATION

# A method of manufacturing a longitudinally extending rack member for a rack and pinion assembly

This invention relates to a method of manufacturing a longitudinally extending rack member for a rack and pinion assembly.

Rack and pinion assemblies are well known, particularly in the art of steering gears, whereby the rack member has a longitudinally extending array of rack teeth each of which extends laterally of that member. When incorporated in a rack and pinion assembly, the rack member is longitudinally displaceable in a housing while the rack teeth engage with the teeth of a rotatably mounted pinion, so that upon rotation of the pinion the rack is displaced longitudinally. The teeth of the rack member can take many different profiles to provide the desired engagement with the pinion and a required ratio of drive which is transmitted through the assembly usually from the pinion to the rack bar. In use the rack teeth can be subjected to considerable shear forces, especially in a steering gear installation and consequently the material and profile of the teeth must be of a form and design which is sufficient to withstand such forces and thereby alleviate fracture of the teeth.

It has previously been proposed to manufacture a rack member as described above from a tubular workpiece to provide a relatively lightweight structure. In such a technique, an example of which is disclosed in U.S. Patent No. 4,133,221, a collapsible mandrel is inserted into the tube, the wall of the workpiece is displaced radially inwardly over the mandrel to form the rack teeth and the mandrel is then collapsed and withdrawn from the workpiece. The radial displacement of the workpiece wall is effected by a die part which is generally complementary to the opposing die part formed by the collapsible mandrel so that the wall of workpiece adopts a corrugated profile corresponding to the desired tooth formation when the wall is pressed between the opposed die parts. It is necessary for the mandrel to collapse to ensure that it is sufficiently clear of the internal profile of the formed teeth to permit its withdrawal from the rack member; such a collapsible mandrel is relatively expensive to produce and is expensive to use in that it is time consuming to collapse and withdraw following a tooth forming operation and also to assemble and locate in preparation for a tooth forming operation.

It is an object of the present invention to provide a method of manufacturing a rack member which may be relatively lightweight and which method is relatively inexpensive, is applicable to a wide variation of tooth structure – this variation may be as between one type of rack and another or as between individual teeth on the same rack where variable ratio steering is involved and it facilitates the manufacture of robust teeth.

According to the present invention there is provided a method of manufacturing a longitudinally extending rack member for a rack and pinion assembly, said member having a longitudinally extending array of rack teeth each tooth of which extends laterally of the member and which method comprises providing a metal bar which is tubular at least over its longitudinal extent where the rack teeth are to be formed, collapsing the wall of the bar substantially to close the bore and displacing the material of the bar to form therein the array of rack teeth on the collapsed wall of the bar.

Further according to the present invention there is provided a longitudinally extending rack member when manufactured by the method as specified in the immediately preceding paragraph.

By the method of the present invention the wall of the tubular bar can be collapsed to substantially close the bore over the length (or appropriate part length) of the bar and the material of the collapsed wall subsequently displaced to form the rack teeth. Preferably however the collapsing of the tubular bar (or the required longitudinal extent thereof) is effected simultaneously with the displacement of the bar material to form the rack teeth.

The displacement of the bar material to form the rack teeth can be achieved by a forging technique but it is preferred that a press technique is utilised, particularly coin pressing. Coin pressing is well known for metal shaping whereby the shape of a metal blank is changed without a change in volume by subjecting the blank to pressure between opposed dies so that the metal is displaced into a form determined by the die cavity. This coin pressing technique can be applied to the manufacture of a rack member in accordance with the present invention whereby the tubular metal bar workpiece is subjected to pressure between dies causing the wall of the tube to collapse (if not already collapsed) simultaneously with the formation of the rack teeth. Furthermore, by arranging for the grain of the tubular metal bar to extend longitudinally of the bar, an advantage can be provided whereby the grain will substantially follow the form of each tooth in the array of coin pressed teeth to be continuous over such array and each tooth is devoid of end grain (which alleviates fracture of the teeth). In conventional manufacture of rack members where the teeth are subjected to a machining operation, the cutting of the metal workpiece causes end grain to be exposed in the flanks of the teeth with the result that when the teeth are subjected to shear forces during use of the rack member the discontinuous grain can provide lines of weakness along which the teeth can fracture. Coin pressing permits an accurately shaped rack to be formed solely as a result of the pressing operation which avoids the requirement for subsequent machining and by arranging for the grain of the rack member to follow the form of each tooth and to be continuous longitudinally over the array of rack teeth so that each tooth is devoid of end grain as aforementioned, the grain provides continuous longitudinal support throughout the teeth to withstand

the aforementioned shear forces. Furthermore, by appropriate selection of the opposed dies between which the metal bar is coin pressed the array of rack teeth can be shaped with widely different profiles, both one rack as compared with another or between different teeth on a common rack as would be the case with a variable ratio rack member.

The metal bar will usually, but not essentially, be tubular over the whole of its length and the wall of such bar may be collapsed to substantially close the bore over part length only of the bar (which part length is appropriate for the length of the rack teeth) while at least one end part length of the bar is retained in tubular form. This facilitates the manufacture of a relatively light weight rack member with reduced material costs and also the tubular part length or lengths which are retained on the rack member can provide convenient coupling points or housings, for example, to mate with or receive ball joints by which the rack member can be connected to control links in a steering gear.

If required the bar can be heated, say at least over the part length of the bar within which the rack teeth are to be formed, to facilitate flow of the metal during coin pressing. Conventional rack members are usually machined from high carbon steel which is then hardened whereby the surface of the member is heated and is then cooled rapidly by quenching. High carbon steel is expensive in comparison with low carbon steel and the possibility is envisaged that the tubular metal bar from which the rack member of the present invention is to be formed may be of a low carbon steel which, by subjection to the coin pressing operation becomes work hardened. By arranging for the grain of the rack member to extend continuously through the rack teeth and by having each tooth devoid of end grain it is possible that the strength which this affords to the rack teeth will alleviate the requirement for a hard surface to be provided on the teeth by use of expensive high carbon steel and that the less expensive lower carbon steel may be suitable as aforementioned.

The internal profile of the opposed dies, particularly the part of the profile which is complementary to the rack teeth, can be formed under computer control. This is particularly advantageous where the rack teeth are, for example, to be non-uniform as in the case of a variable ratio rack and pinion gear which incorporates a standard uniformly toothed pinion. With this in mind the form of the proposed rack teeth may be determined mathematically and a computer programme may be produced in accordance with such theoretical calculation; this programme may then be utilised to computer control an appropriate tool for machining the desired profile on the die with which die the rack teeth are to be coin pressed.

One embodiment of a method of manufacturing a rack member for a rack and pinion assembly and in accordance with the present invention will now be described, by way of example only, with reference to the accompanying illustrative drawings, in which:–

Figure 1 is a side elevation of a longitudinally extending tubular metal bar from which the rack member is to be formed;

Figure 2 is a radial section of the bar in Figure 1;

Figure 3 is a side elevation of the opposed dies of a coining press and diagrammatically illustrates the manner in which the bar of Figure 1 is subjected to deformation by coin pressing;

Figure 4 is a side elevation of part of the rack member formed by a coin pressing technique and from a bar shown in Figure 1 and diagrammatically illustrates the grain in the rack member;

Figures 5 and 6 are radial sections of the metal bar during and following the deformation thereof and are used to diagrammatically illustrate a preferred volume relationship between the size of the bore of the tube in Figure 1 and the size of the formed rack teeth and

Figure 7 is a side elevation of a modified form of tubular metal bar from which the rack member can be formed.

The longitudinally extending tubular metal bar 1 shown in Figure 1 may be of low carbon steel, is generally cylindrical and is provided with a cylindrical bore 2. Male or female screw threads (not shown) can be provided at each end of the bar to provide a convenient means of coupling linkage members to the rack member which is to be formed from the bar and when incorporated in a rack and pinion assembly (as for example in a steering gear installation). The bar 1 is formed, for example by a rolling process, so that the grain thereof extends longitudinally and continuously throughout the length of the bar.

Part length of the bar 1 remote from its tubular end part lengths is subjected to a coin pressing operation as shown in Figure 3 whereby the wall of the bar over the desired longitudinal extent of the rack teeth which are to be formed is collapsed to close the bore 2 (Figure 6) and the metal of the bar in this region is displaced to provide a longitudinally extending array of rack teeth 4 (see Figure 4) each tooth 4*a* of which extends laterally of the bar 1.

As shown in Figure 3 the bar 1 is located between the upper and lower dies 5 and 6 of a coin press of which the cavity 7 in the upper die 5 is of complementary shape to the array of rack teeth 34 which are to be formed on the bar 1. The dies 5 and 6 are closed under pressure to cause, substantially simultaneously, the wall of the bar 1 to collapse and the material of the bar to be displaced and flow into the toothed regions of the cavity 7 and thereby mould the teeth 4*a* to such accuracy that subsequent machining of the rack is avoided. It is believed that the considerable pressure to which the material of the bar 1 is subjected during coin pressing will work harden the surface of the rack teeth 4*a* sufficiently to withstand the wear to which they are likely to be subjected in use even though the bar metal is of low carbon steel. If required the bar 1 can be heated prior to the coin pressing operation to facilitate the metal displacement between the dies 5 and 6.

The cavity formed between the closed dies 5 and 6 is of course accurately shaped to correspond with the rack teeth 4*a* irrespective of whether all of the teeth are of the same profile and dimensions for a standard rack or whether the teeth differ one from the other as in the case of a variable ratio rack. Furthermore, the dies 5 and 6 serve to change the

shape of the metal of the bar 1 over the part length of the bar where the rack 4 is to be formed without changing the volume of the metal in that region. For the purposes of calculation it may be assumed that when the wall of the bar 1 is collapsed to close the bore 2 (as shown at 2*a* in Figure 6) a recess 8 is formed in the peripheral surface of what may be considered to be a solid bar over the length of the collapsed bore part 2*a* and the volume of the recess 8 is equal to the volume of the bore part 2 prior to the closing of that bore part. From these considerations the dimensions of the bore 2 and the diameter of the bar 1 which are required to provide rack teeth 4*a* with desired pitch, profile and depth characteristics (as indicated in Figure 5 where the depth of the teeth 4*c* is shown at 4*b*) can be calculated without difficulty.

During displacement of the metal in the coin pressing operation to form the teeth 4*a* the grain of the bar which was continuous over the length of the bar maintains its continuity as indicated by the chain lines 9 in Figure 4 but is displaced as indicated at 9*a* to substantially follow the form of each tooth. Since the teeth 4*a* are formed with such accuracy that their subsequent machining is avoided, each tooth 4*a* is devoid of end grain and the continuous grain throughout the array of rack teeth provides reinforcement which serves to alleviate fracture of the teeth, particularly over their crests.

In the event that the rack member is to be formed from a thin walled tubular bar (as for example may be required to reduce weight) such a bar shown at 1*a* in Figure 7 may be provided with a tubular metal plug 1*b* over the longitudinal extent where the rack teeth are to be formed. During the tooth forming operation the wall of the plug 1*b* is collapsed to close the bore thereof while the metal of the plug together with the metal of the bar 1*a* is displaced, preferably by the coin pressing technique above described, to form the array of rack teeth.

CLAIMS

1. A method of manufacturing a longitudinally extending rack member for a rack and pinion assembly, said member having a longitudinally extending array of rack teeth each tooth of which extends laterally of the member and which method comprises providing a metal bar which is tubular at least over its longitudinal extent where the rack teeth are to be formed, collapsing the wall of the bar substantially to close the bore and displacing the material of the bar to form therein the array of rack teeth on the collapsed wall of the bar.

2. A method as claimed in claim 1 which comprises collapsing the tubular bar or the required longitudinal extent thereof substantially simultaneously with the displacement of the bar material to form the rack teeth.

3. A method as claimed in either claim 1 or claim 2 in which the metal bar is tubular over its longitudinal extent and the method comprises collapsing the wall of said bar substantially to close the bore over part length of the longitudinal extent of the bar while retaining at least one end part length of the bar in tubular form.

4. A method as claimed in any one of the preceding claims in which the volume of the bore of the bar over the length thereof in which the rack teeth are to be formed substantially corresponds to the volume of a longitudinally extending recess which would be formed in a solid bar and within the extent of which recess the material of the solid bar would be displaced to form an array of rack teeth corresponding to that array which would be formed from the tubular bar.

5. A method as claimed in any one of the preceding claims which comprises locating in the bore of the metal bar a tubular metal plug, collapsing the wall of the tubular bar together with the wall of the plug substantially to close the bore of the plug and displacing the material of said plug and bar to form the array of rack teeth.

6. A method as claimed in any one of the preceding claims which comprises providing the tubular bar with its grain extending longitudinally thereof and coin pressing the bar to form therein the array of rack teeth so that the grain substantially follows the form of each tooth to be continuous over the array of rack teeth and each tooth is devoid of end grain, the teeth thus formed not being subjected to subsequent machining.

7. A method as claimed in any one of the preceding claims in which the tubular bar is substantially cylindrical.

8. A method as claimed in any one of the preceding claims which comprises heating the bar, at least over the part length thereof within which the rack teeth are to be formed, to facilitate flow of the metal during displacement thereof.

9. A method as claimed in any one of the preceding claims which comprises work hardening the surface of the rack teeth by coin pressing the teeth in the bar.

10. A method as claimed in any one of the preceding claims which comprises determining mathematically the form of the rack teeth which are to be provided for the rack member; producing a computer programme in accordance with said mathematical determination; utilising said programme to computer control a tool to machine on a coin pressing die component a profile which is complementary to said rack teeth and applying the so machined die to coin press the rack teeth in the metal bar.

11. A method of manufacturing a longitudinally extending rack member for a rack and pinion assembly substantially as herein described with reference to the accompanying illustrative drawings.

12. A rack member when manufactured by the method as claimed in any one of the preceding claims.

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# (54) Method of making steering racks

(57) A method of making racks for rack and pinion steering gears for ground vehicles in which a rack blank is first shaped by machining, forging or other means having teeth which have a form corresponding approximately to the form desired in the finished rack the form of each tooth in the blank corresponds to the finished shape but is generally of greater radius; the total height of the tooth being greater than that of the finished shape and the volume of each tooth is substantially the same as the finished tooth. The teeth are then converted to the finished form by cold forming or coining in a die having a shape which is the exact counterpart of the finished shape.

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The drawing(s) originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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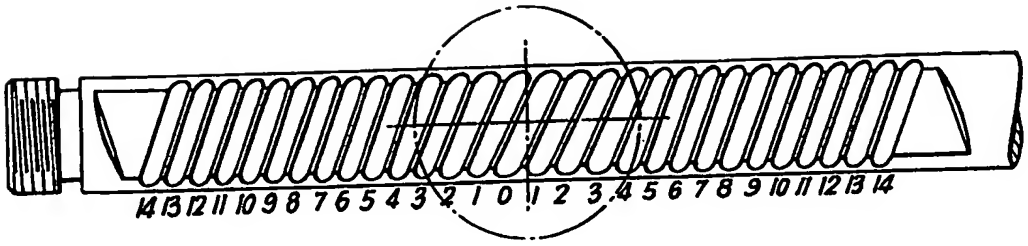



Fig.1.

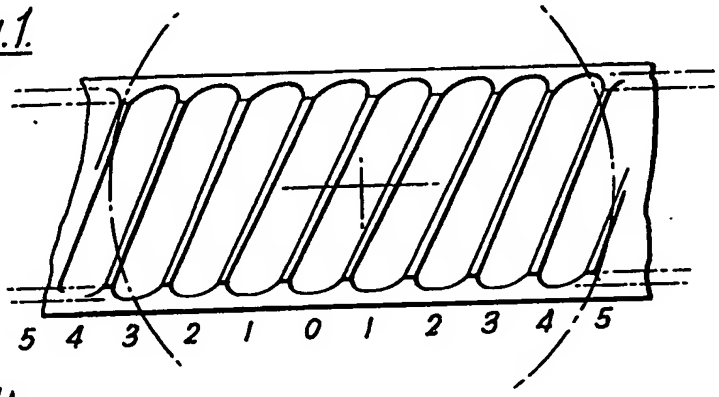



Fig.1A.

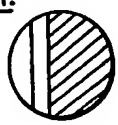


Fig.1B.

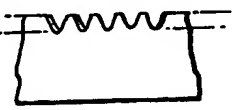


Fig.4.

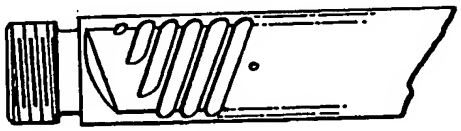


Fig.5.

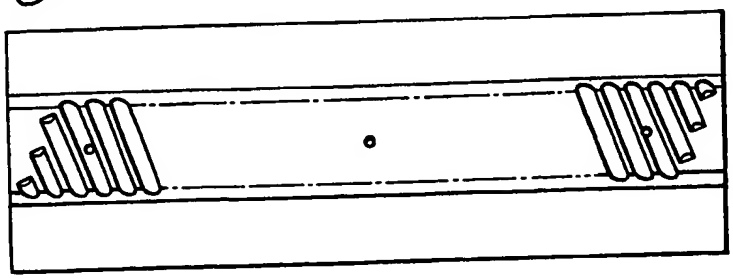


Fig.2.

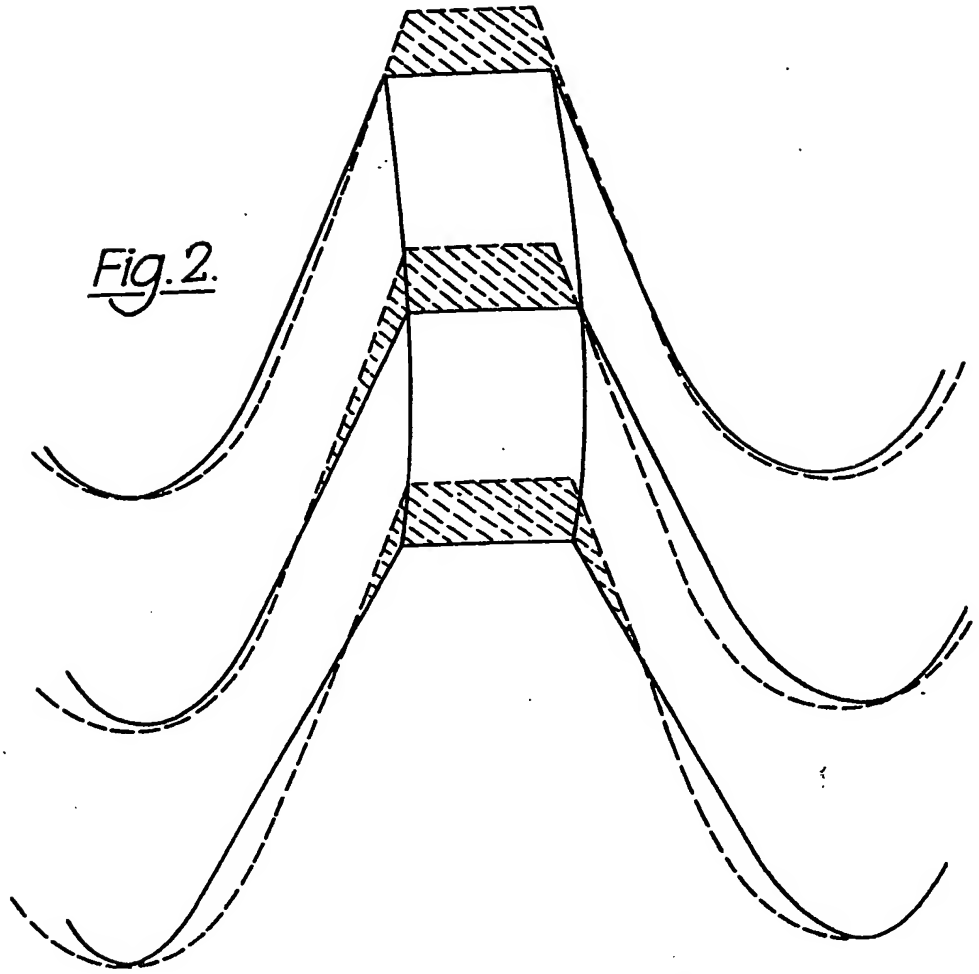
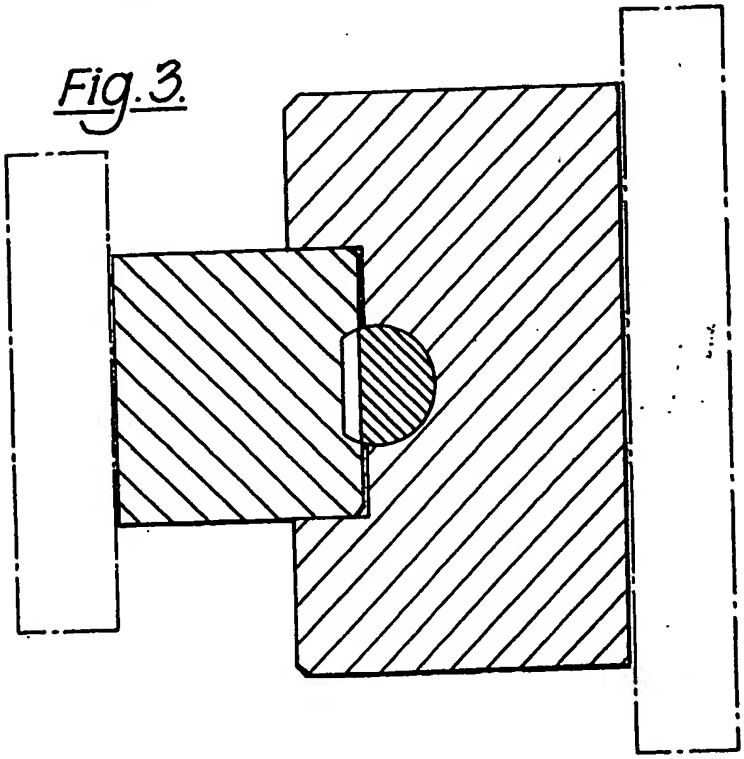


Fig.3.



SPECIFICATION

## Method of making steering racks

This invention relates to a method of making racks for rack and pinion steering gears for ground vehicles and is particularly, although not exclusively, applicable to the type of rack which provides a variable steering ratio, that is one in which a rack moves at a variable rate upon rotation at a constant rate of the steering wheel.

Such variability may be advantageous in a power steering gear to allow the use of a high steering ratio on center where speeds may be high and a substantially lower steering ratio away from center where speeds will generally be much lower, for example, as shown in Australian Patent 241798.

Alternatively in a manual steering gear, a variable ratio may be desired having an increase in steering ratio each side of center in order to reduce the steering efforts towards the lock where, conventionally, the steering efforts tend to be excessive.

Examples of such variable ratio gears appear in U.S. Patent 3,267,763 (Merit) and U.S. Patent Re 28740 (Bishop).

The steering racks used in these several types of variable ratio steering gears employ teeth which differ from standard teeth in several respects and which may vary in shape from tooth to tooth along the length of the rack. In the last named of the three above patents the teeth may in fact vary in shape along the length of any one tooth of the rack. Such teeth may be very difficult to form to a high degree of accuracy by any known manufacturing method.

It should be observed that high accuracy is essential if the rack teeth are to sustain the great loads to which such steering gears are subject and if a smooth tooth action is to be achieved so as to avoid undesirable jerkiness and to ensure the highest possible efficiency of operation.

It is also important that the teeth of such a steering rack have a very accurate finish in the root or fillet areas of the teeth and that the material in this area be free from longitudinal, (in relation to the length of the tooth,) defects or cutting marks.

A high degree of accuracy and finish is important not only in the case of variable ratio racks but also in the case of standard steering racks of the simplest kind intended to mesh with a straight cut pinion so that the method to be described is equally applicable to such standard racks.

In my co-pending Australian Patent Application No. 9216/77, British Patent No. 1,551,699, "Method of manufacturing variable ratio racks" I describe a method of making steering racks of the type described in the last named patent and in specific detail a method of rough machining such racks prior to exact finishing by a finishing process in which the racks are "deformed or otherwise shaped".

In the method of manufacture of steering racks which is the subject of the present invention this deforming is by cold forming under great pressure in a die which is the exact reverse facsimile of the desired shape of the finished rack.

Such dies can be made to a great order of accuracy and it follows that a rack finished by the method described will have imparted to it the high accuracy of the die, furthermore as the die is highly finished, the rack will also have tooth faces which are highly finished and free from longitudinal score marks which have been made by the roughing process and which are generally characteristic of other conventional methods of manufacturing racks. Such longitudinal marks are prone to start cracks in such highly loaded teeth which are subject to fatigue type stress reversals.

It may be thought that it would be possible to cold form such racks by taking a blank of steel and impressing teeth therein in a die, in the manner well known in the art of cold forming. However there are several reasons why such methods are not suitable in the case of steering racks. Firstly, in such cold forming, it is usual to fully contain the workpiece within the die so when the die fully closes the material is subject to very intense internal pressures and flows in the manner of a fluid. In order to so flow, it is accepted practice to use materials having high ductility, but such materials are not suitable for the manufacture of steering racks, for which purpose a material such as a carbon steel having .45% carbon is specifically used. Such material tends to work harden and tends to be poorly adapted to cold forming. Moreover the rack bar of a steering rack as generally used is of some considerable length for example 24" and the area to be formed into teeth occupies maybe 1/10th of the surface area of such a rack bar. The fully containing of such a large body, wherein such high pressures are to be developed would be very difficult to achieve in any known process. This will be more the case because the material commonly used has such reluctance to flow. It is for this reason that in the method described earlier the teeth are rough machined to an approximation of the finished shape, and in cold forming are merely set to the exact finished form required.

In one important further refinement of this process the preformed teeth are not merely a rough facsimile of the finished form, but rather a distorted form in which certain specific rules are observed. For example, it has been found that the rough formed tooth should have in the root or fillet areas a form closely approximating the finished shape but of larger radius; the total height of the tooth however should be substantially greater than the finished height and it should in most cases, but not all, have a narrower tip. There will be areas just above the root area in which the tooth in its rough machined form will be narrower than in its final form and it is into these areas that surplus metal from the tip will be displaced during the cold forming or coining operation. Furthermore the volume of the tooth as rough machined should be substantially the same as or slightly greater than that desired in the finished tooth. (Some variation may, however, be expected to occur due to densification of metal, or minor flow to other areas.) A very important aspect of this refinement is that the amount of flow of metal occurring is greatly reduced from the situation where metal may be required to flow up into the

cavity of the die in order to fill the difference between the final desired shape and the rough formed tooth. Essentially the process of forming the tooth thereby becomes one of successively squashing down layers of the tooth from the tip towards the root so that the material merely flows laterally in section until it touches the die cavity whereupon a layer of tooth below the first element worked also flows laterally to occupy its available space. By such a means the amount of flow taking place in any one element of the steel is greatly reduced and hence the material of low ductility can be worked satisfactorily. A further point is that, upon fully closing the die there is little tendency for the entire material of the core of the rack bar to be extruded lengthwise as would happen if the amount of fill varied along the length of the rack and hence surplus material had to be extruded lengthwise along a section of the bar, such extrusion lengthwise in the base stock of the rack might well sever certain teeth by shear or cause undesirable metallurgical properties in the root area of such teeth. A further important advantage of the process described in regard to the preformed shape is that there is little sliding of the metal being formed across the face of the die, and hence wear on the die is greatly reduced as compared with the accepted practices in cold forming. This aspect is most important where variable ratio racks are employed as the production of dies is a very expensive and elaborate process.

In a further refinement it should be noted that, in contrast to accepted practice in cold forming, the closing of the die would be limited according to the final closing pressure rather than to the shut height of the die. Thus when flow had occurred to substantially but not completely all of the root area of each tooth, closing of the die would cease.

The invention thus comprises a method of making racks for rack and pinion steering gears wherein a rack blank is first shaped to produce in it a plurality of rack teeth each tooth being shaped to form a corresponding approximately to the form desired in the finished rack, the form of the tooth in the root or fillet area corresponding fairly closely to the finished shape but being generally of a greater radius, the total height of the tooth being greater than that of the finished shape, and the volume of the tooth being substantially the same as the volume of the finished tooth, the teeth of the rack being converted to the finished form by cold forming or coining in a die having a shape which is the exact counterpart of the finished shape of the teeth.

The initial machining of the rack may be carried out in a variety of different ways for example by broaching, milling or a gear cutting operation.

In order that the nature of the invention may be better understood a preferred form thereof is hereinafter described by way of example with reference to the accompanying drawings in which:-

*Figure 1* is a plan view of a rack for use in variable ratio rack and pinion steering gear,

*Figure 1a* is a section on V-V of Figure 1,

*Figure 1b* is a view in the direction of the arrow A,

*Figure 2* is a view of a tooth of Figure 1 to an enlarged scale showing sections of the tooth at each end and in the middle both for the finished tooth and the rough machined tooth,

*Figure 3* is a sectional view of the two halves of a rack coining die in the closed position,

*Figure 4* is a view of a portion of a rack showing the shape of some of the teeth before the coining operation, and

*Figure 5* is a view of the top half of the coining die showing the counterpart of the finished form of the rack teeth.

The rack illustrated in Figure 1 is an example of a rack for a variable ratio rack and pinion steering which can be manufactured by the method according to the present invention. The difficulties of making such a rack can be appreciated from the variations in the form of the rack teeth. It is however to be emphasized that the method can be used with advantage in the manufacture of racks of simple and straight forward design in which the teeth are all the same and are arranged at right angles to the axis of the rack.

During the process of manufacture, the teeth of the rack are first machined in rough form by broaching for example by the method described in the specification of the abovementioned Australian Patent Application. Other forms of machining such as milling or gear cutting may be adopted or the rack in rough form may be manufactured by a precise hot forging process or what is known as a warm forging process at about 1350°F. The object of the initial machining or forging operation is however to produce teeth corresponding fairly closely in shape to the finished form of the teeth for the rack but differing from them in a quite specific manner. This is illustrated in Figure 2 showing a view of a tooth of Figure 1 to a much enlarged scale and illustrating the sectional shape of the tooth at each end and at a point near the middle. In this figure the full lines represent the finished tooth shape, whereas the broken lines represent the rough machined shape of the tooth. From this figure it will be seen that at the root or fillet area on either side of the tooth the full lines and the broken lines coincide at one or more points. In areas above this on either side of the tooth the full line lies outside the broken line indicating that the tooth in its rough machined form is narrower here than in the finished form. In all three of the sections shown the tooth in its rough machined form is greater in height than the tooth in its final form and in the two nearer sections the tooth in its rough machined form is wider than in its finished form. The hatched areas of each section indicate metal available for displacement to fill the areas nearer the root of the teeth where the rough machined form is narrower than the finished form. In general the angles made between the flank of a tooth in its rough form will subtend an angle smaller than the angle subtended by those flanks of the tooth in its finished form.

The rack is finished by a cold forming or coining operation in which the surplus metal towards the tip of each tooth is displaced to fill the areas nearer the root. As can be seen from Figure 2 the volume of the tooth in its rough machine form is substantially

equal to the volume of the finished tooth and thus substantially all displacement of metal takes place within the volume of the tooth thus avoiding the disadvantages described above.

Figure 3 shows the coining die used for finishing the rack, the bottom half of the die serving to locate the rack bar and the top half serving to impart to the teeth of the rack the precise form desired.

Figure 4 shows some of the teeth of a rack in their rough machined form and Figure 5 shows the interior of the top half of the coining die in which a counterpart of the teeth of the rack in the finished form are incorporated. As is described above the interior surface of the top half of the coining die is very finely finished and during the coining operation imparts this high finish to the rack teeth thus serving to form them very precisely to the desired shape and also to do so without the formation of score marks. The coining operation itself is carried out in a conventional manner.

While the rack illustrated in the drawings is made from a bar of substantially circular cross-section the invention may advantageously be applied to racks of the cross-section illustrated in Figure 4 of Australian Patent 498666.

CLAIMS

1. A method of making racks for rack and pinion steering gears wherein a rack blank is first shaped to produce in it a plurality of rack teeth each tooth being shaped to a form corresponding approximately to the form desired in the finished rack, the form of the tooth in the root or fillet area corresponding fairly closely to the finished shape but being generally of a greater radius, the total height of the tooth being greater than that of the finished shape, and the volume of the tooth being substantially the same as the volume of the finished tooth, the teeth of the rack being converted to the finished form by cold forming or coining in a die having a shape which is the exact counterpart of the finished shape of the teeth.

2. A method of making racks as claimed in claim 1 wherein in the rack blank the angle subtended between the flanks of any one tooth is smaller than the angles subtended by those flanks in the finished rack.

3. A method as claimed in Claim 1 or Claim 2 wherein the rack blank is first shaped by machining.

4. A method of making racks as claimed in Claim 1 or Claim 2 wherein a rack blank is first shaped by hot forging.

5. A method of making racks as claimed in Claim 1 or Claim 2 wherein a rack blank is first shaped by warm forging.

6. A method of making racks for rack and pinion steering gears substantially as described with reference to and as illustrated in the accompanying drawings.

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